Yale University

School of Forestry

THE SEASONING PROPERTIES OF DETERMA

(*Ocotea rubra* Mez.)

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Technical Report No. 5

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The Seasoning Properties of Determa (*Ocotea rubra* Mez.) [1]

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by
Fred E. Dickinson

This study is one of a series undertaken as part of a continuing investigation of the properties of tropical woods. The investigation is being conducted at the Yale School of Forestry and is sponsored by the Office of Naval Research, Department of the Navy, under Contract N6ori-44, Task Order XV (Project Designation NR-033-020). The scope of the complete research program is indicated in Properties and Uses of Tropical Woods, I published in TROPICAL WOODS 95 (June 1, 1949).

Determa which is closely related to Greenheart (*Ocotea Rodiaei*) is a wood possessing characteristics which make it suitable for numerous uses including furniture and cabinet manufacture, interior and exterior trim, and tank stock. While slightly less dense than Yellow Birch (specific gravity of 0.62 based on oven-dry volume compared with 0.66 for Yellow Birch) it is equal to or better than it in all mechanical strength properties other than shock resistance, hardness, and shear. Shrinkage is moderate for a wood of its density class. As shown in the accompanying tabulation the material from Surinam has a lower tangential and volumetric shrinkage than that from Brazil.

[1] Part of the basic data on which this report is based was collected by Dean B. Chandler and Mitchell R. Samborski in special studies as partial fulfillment for the requirement for the M. F. degree at the School of Forestry, Yale University.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Determa[1] (Ocotea rubra) Surinam	4.0	7.7	0.30	11.6
Lauro Vermelho[2] Brazil	4.0	10.0	—	15.9
Yellow Birch[3] (Betula lutea) United States	7.2	9.2		16.7

/1 Tropical Woods 95 (4)
/2 Brotero and Vieira (3)
/3 U. S. Dept. Agr. Tech. Bul. 479

In order to gain information on the seasoning characteristics of this species several lots of material were air seasoned and kiln dried. In addition studies were made of the movement of moisture in the wood as moisture absorption studies (2) had shown a very low rate of absorption by the heartwood, indicating a low moisture diffusion rate.

Air Seasoning of Determa

Both 5/4-inch boards and 2 1/2 by 2 1/2-inch squares 4 feet long from three 8-foot logs of Determa from Surinam were air seasoned in a well ventilated storage shed. The material was piled on foundations which provided for adequate ventilation under the piles. All piles were 4 feet wide and not over 4 feet in height. Dry stickers 3/4 inch thick by 1 inch wide spaced every foot were used. Adjacent boards and squares were kept approximately 3/4 inch apart to insure vertical circulation through the pile. All material was end coated with filled hardened gloss oil.

No particular problems were encountered in the air seasoning of this material. The squares developed a slight amount of crook while the 5/4-inch boards showed slight cup and crook. Both end and surface checking were noticeable in a small percentage of the pieces.

The moisture content of the stock at the time of piling in April ranged from 67 to 62 percent. Approximately six to eight months were required to dry the stock down to an average moisutre content of 16 percent, the longer time being required for the squares. At the end of the drying period the moisture content at the center of the squares was still above the fiber saturation point indicating the need for a considerable longer drying period for thick stock if a relatively uniform moisture content below 20 percent is desired.

Kiln Drying of Deberma

The problem of arriving at a schedule suitable for the drying of this wood is accentuated by the very slow rate of moisture diffusion and the marked tendency for collapse when attempts are made to materially increase the diffusion rate.

Figure 1 illustrates the moisture gradient pattern of 1-inch stock during a seven-week drying period under controlled conditions. Weekly, a cross-section was cut from the drying material and in turn sawn into seven strips so as to determine the moisture content pattern from surface to surface. The moisture contents of the paired zones have been averaged for each week and thus figure 1 shows the moisture gradient for only one half the thickness of the piece. Examination of the chart indicates that during the first three weeks approximately only the outer one-seventh of the cross-section was below the fiber saturation point. It was not until the sixth week that the entire cross-section was below the fiber saturation point even though the material had been subjected to an equilibrium moisture content condition of ten percent and less from the middle of the second week until the end of the drying period.

Figure 2 shows the moisture content of the zones at weekly intervals in relation to the drying schedule. Here again is illustrated the slow

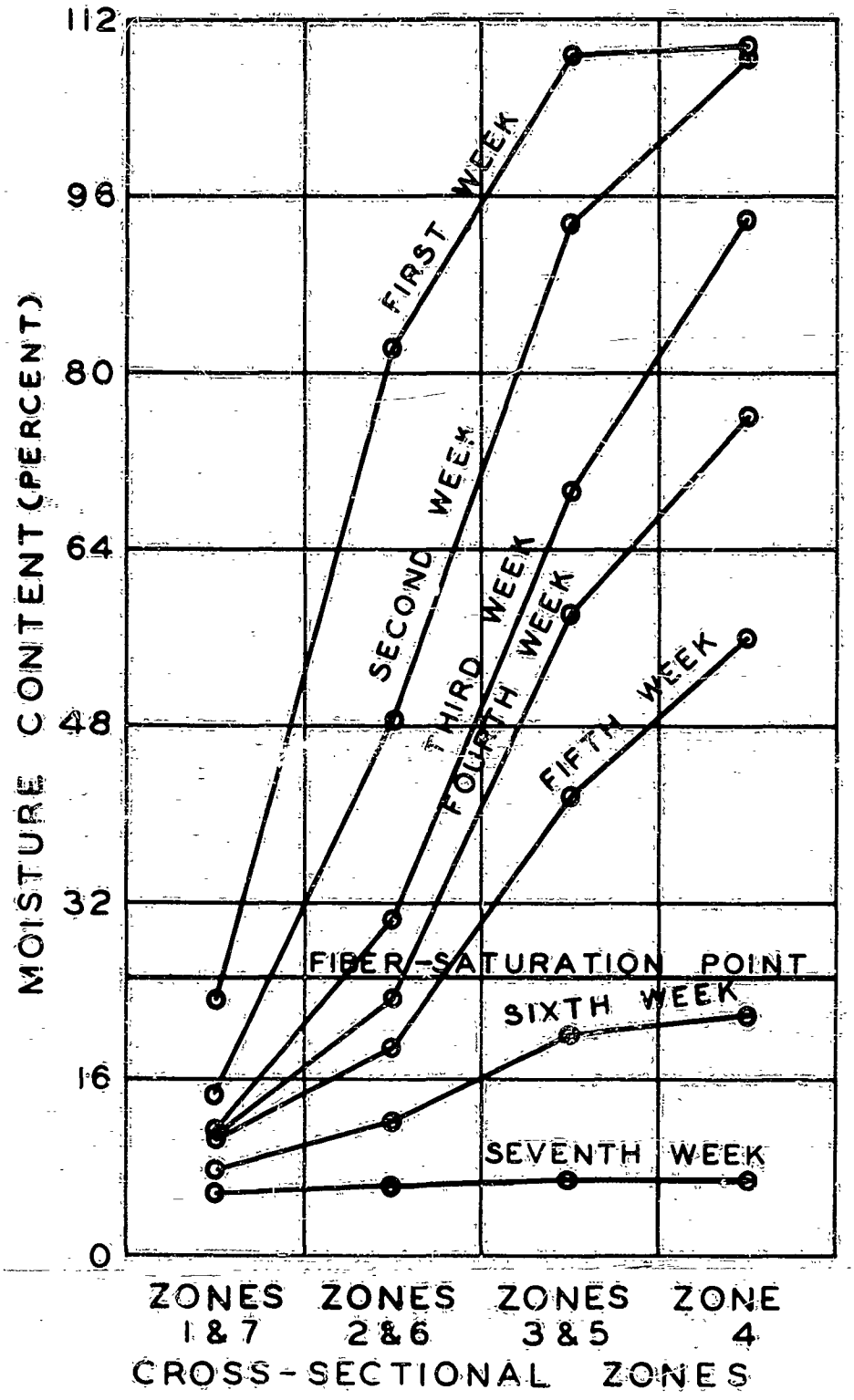

FIG. 1 WEEKLY MOISTURE GRADIENTS IN A 1-BY 10-INCH FLAT-SAWED DETERMA BOARD DURING KILN DRYING.

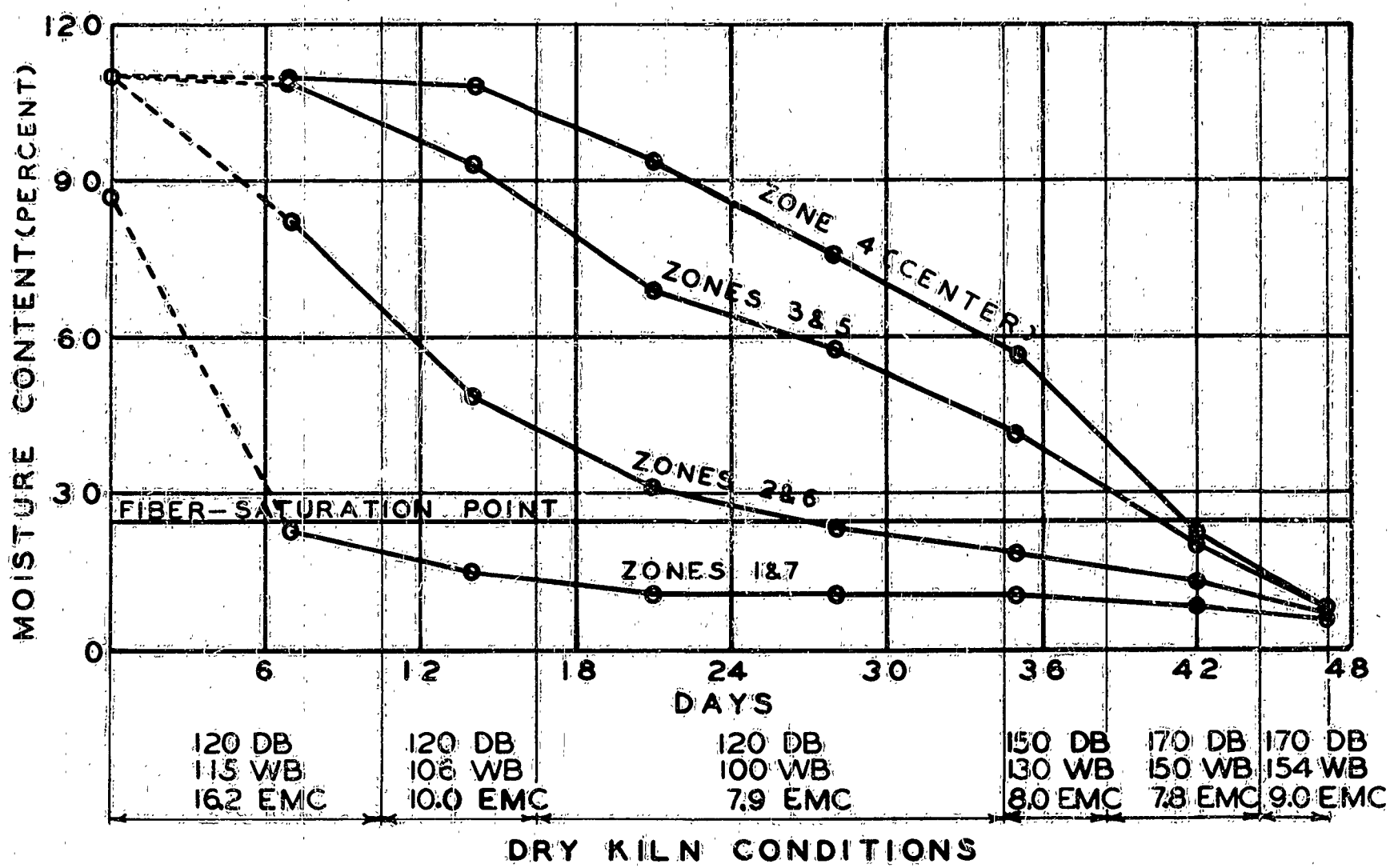

FIG. 2 CHANGES IN MOISTURE CONTENT IN DIFFERENT ZONES OF A 1- BY 10-INCH FLAT-SAWED DETERMA BOARD DURING KILN DRYING.

rate of moisture passage from the interior to the surface. The pattern is somewhat similar to that for 2-inch Red Gum (Liquidamber styrasiflua) heartwood as determined by the U. S. Forest Products Laboratory (1). Considering that part of the cross-section of the Red Gum one-half inch in from the surface which would be equivalent to the center of the 1-inch stock used in this study, the moisture content of the Gum had fallen below the fiber saturation point after approximately 30 days while the moisture content at the center of the Determa stock did not fall below this point until after approximately 40 days. In addition, the drying of a section one-half inch in from the surface in 2-inch stock would be undoubtedly somewhat slower than the drying of the center of 1-inch stock. A part of the difference between the drying rate of the two species can be accounted for by the use of a more extreme schedule with the Gum which would produce a faster rate of diffusion, 135 degrees Fahr. and an equilibrium moisture content condition of 5 1/2 percent and less for all but the first 8 days of the drying period. A temperature this high is impossible to use with freshly sawn Determa stock because of the danger of collapse.

While the equilibrium moisture content of Ocotea rubra was not determined at various conditions of temperature and relative humidity, it was found that when conditions in the dry kiln were set at 9 percent equilibrium moisture content, based on American woods, Determa attained a moisture content several percent lower.

Four kiln runs were made in a small experimental kiln, plate 1, to determine the maximum temperature and minimum humidity conditions which could be safely used with this species. Using the information gained, a pilot kiln run using 100 board feet of material was made in a kiln capable of being charged with pieces seven feet in length, plate 2. This last run

gave a better idea of how the material would react in a commercial kiln. A rate of air circulation of 300 feet per minute was used in all runs.

In arriving at a drying schedule recognition must be given to the stresses which exist in the wood during the drying period. In the first stage of drying the surface of the wood dries rapidly and starts to shrink as the moisture content falls below the fiber saturation point. This shrinkage is opposed by the wet and non-shrinking center of the piece and thus the surface exerts a tensile force and is said to be in tension. It is at this time that surface checking will occur if too high temperatures and too low humidities are used, causing a stress greater than the strength of wood in tension across the grain. Once the surface of the wood has safely passed this danger point and the inner portions are beginning to dry, the danger of internal checking or honeycombing must be guarded against. Here temperature rather than relative humidity is the important factor as some woods are greatly weakened in compression and tension across the grain when subjected to high temperatures when green.

In addition to surface checking and honeycombing Determa is quite prone to collapse during kiln drying. It was found that this defect could be largely eliminated by the use of a low dry bulb temperature until the moisture content at the center of the stock had dropped to 10 to 15 percent bove the fiber saturation point.

Initial and Intermediate Drying Conditions

All the Determa used in the experiment had a moisture content at the start of the drying period in excess of 90 percent, some of it being as high as 114 percent which is about the maximum that could be expected for a wood of this specific gravity.

Three combinations of initial temperature and relative humidity

conditions were used, namely 160 degrees Fahr. and 90 percent, 140 degrees and 87 percent, and 120 degrees and 85 percent. The first condition resulted in severe end and surface checking, severe cupping, and extreme honeycombing and collapse. No surface checking but severe end checking, even though an end coating material was used, and severe collapse resulted when the second pair of conditions were used. Several runs were made using the third set of conditions with no checking or collapse occurring. Defects resulting from the use of too severe drying conditions are shown in plate 3.

The duration of these initial conditions is important as it is desirable to drop the relative humidity and raise the temperature as soon as possible in order to decrease the drying time through increasing the rate of moisture diffusion. By keeping the temperature at 120 degrees it was found safe to lower the relative humidity to 62 percent after seven days with another drop to 36 percent on the fourteenth day of drying. Care must be exercised in raising the temperature. In one run when the average moisture content of the stock had dropped to 52 percent, the temperature was raised from 120 to 130 degrees Fahr. and the relative humidity increased from 36 to 38 percent. Within a short time after the temperature increase all the boards showed noticeable signs of collapse. However, it was found possible to increase the temperature to 150 degrees when the moisture contnet of the center of the stock reached 40 percent.

Final Drying Conditions

During this final period the drying should be accelerated as much as possible. This can be accomplished by using the maximum temperature and the minimum relative humidity conditions commensurate with safe drying of the stock. With Determa it was found that a dry bulb temperature of 170 degrees could be used when the center of the boards had reached 30 percent without damaging the material. The only practical limitation on relative

humidity is one that will bring the lumber to the desired moisture content.

Equalization and Conditioning

At the end of the run the various boards in the kiln charge will rarely be at the same moisture content. Thus, it is necessary to so adjust the relative humidity as to prevent further drying of the dryer stock but allow continuation of the drying of the greener material. Once all the lumber has attained approximately the same moisture content, conditioning or relief of casehardening stresses can be begun.

This final step is very essential as Determa casehardens severely during drying; see plate 3. The conditioning treatment consists of raising the moisture content of the surface of the stock until it equals or is slightly higher than the moisture content at the core. With Determa this treatment should last for 36 to 48 hours at an equilibrium moisture content condition 2 percent above the moisture content at the core.

Suggested Kiln Drying Schedule

As a result of the several kiln runs the following schedule is suggested for the drying of Determa. Figure 3 is a graphic portrayal of the schedule.

Stage	Dry Bulb Temperature ° Fahr.	Wet Bulb Temperature ° Fahr.	Relative Humidity percent	Duration
1.	120	115	85	168 hours
2.	120	106	62	168 hours
3.	120	93	36	Until the center of stock reaches 40 percent moisture content.
4.	150	120	41	Until center of stock reaches 30 percent moisture content.
5.	170	140	45	Until majority of the stock reaches desired average moisture content.
6.	Equalization at 170° and necessary relative humidity until all boards have approximately the same moisture content.			
7.	Conditioning at 170 degrees at an E.M.C. condition 2 percent above moisture content at center of stock for 36 to 48 hours.			

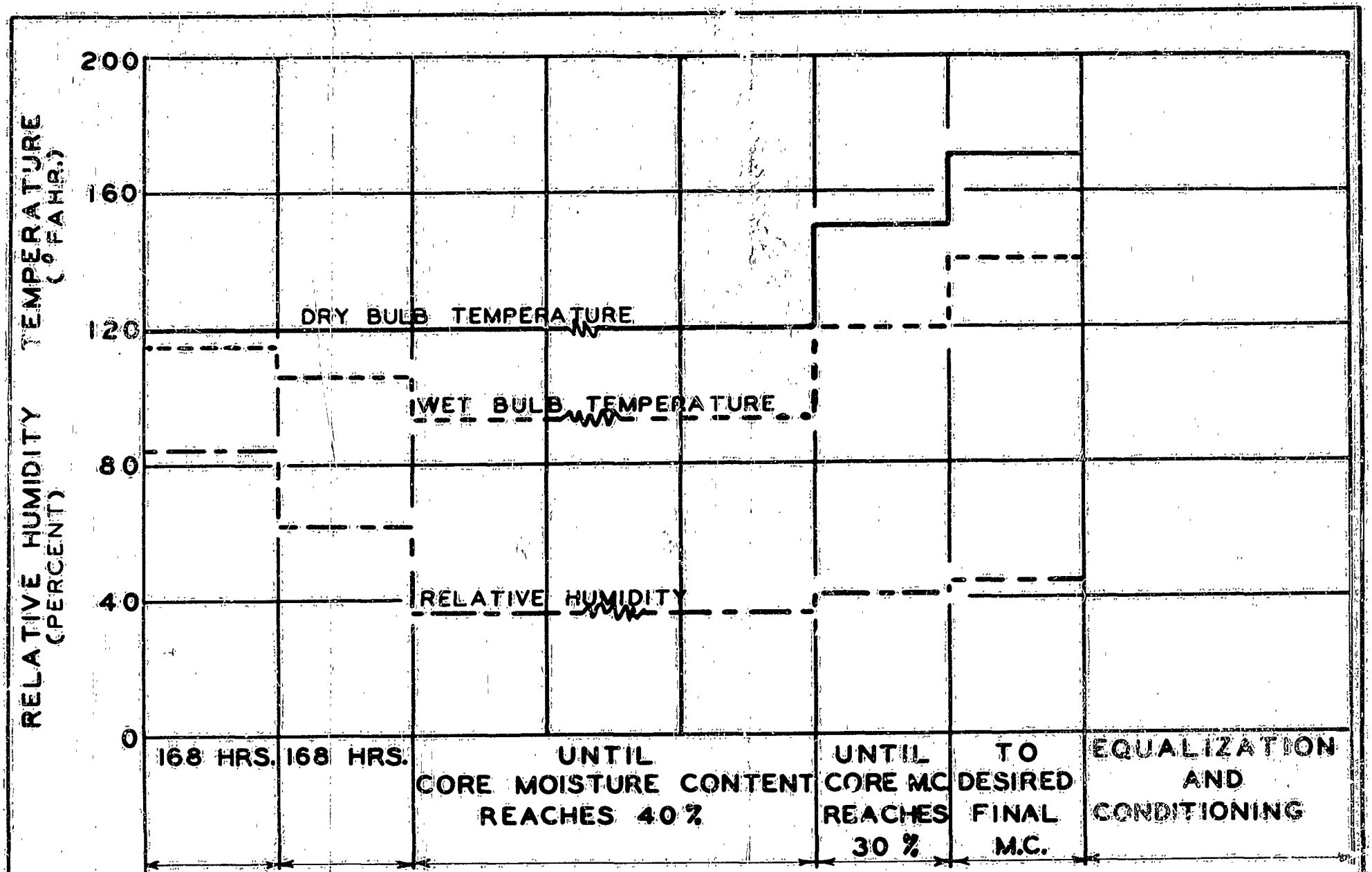

FIG. 3 KILN DRYING SCHEDULE FOR DETERMA.

Application of Schedule

This schedule is designed primarily for 1-inch stock but should be suitable for stock up to 2 inches in thickness.

For air-dry material, if the moisture content at the core is 41 percent or above, kiln drying should be started at stage 2; if the core moisture content is between 30 and 41 percent, stage 3; and for a core moisture content of 30 percent and below, stage 4.

Conclusions

1. Determa presents certain problems in drying due to the slow rate of diffusion of moisture through the wood and the development of collapse if the diffusion rate of free moisture is greatly accelerated.
2. Determa can be successfully air seasoned. Six to eight months are required for 1-inch green stock when piled during the forepart of the year.
3. By the use of a mild kiln schedule in the first part of the run, green Determa can be successfully kiln dried. For stock having a moisture content above 90 percent, drying time will be approximately 6 to 7 weeks.

Literature Cited

1. Army-Navy Civil Committee. Kiln Certification. ANC Bulletin 21. 1946.
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3. Brotero, F. A. and Vieira, A. Tabelas de resultados obtidos para madeiras nacionais. Bul. No. 31, Instituto de Pesquisas Tecnologicas, San Paulo. 1945.
4. Dickinson, Fred E., Hess, Robert W., and Wangaard, Frederick F. Properties and Uses of Tropical Woods, I. Tropical Woods 95: 1-145. 1949.

Plate 1. Small experimental kiln used in the preliminary runs. Kiln charge consists of 4 boards 16 inches long.

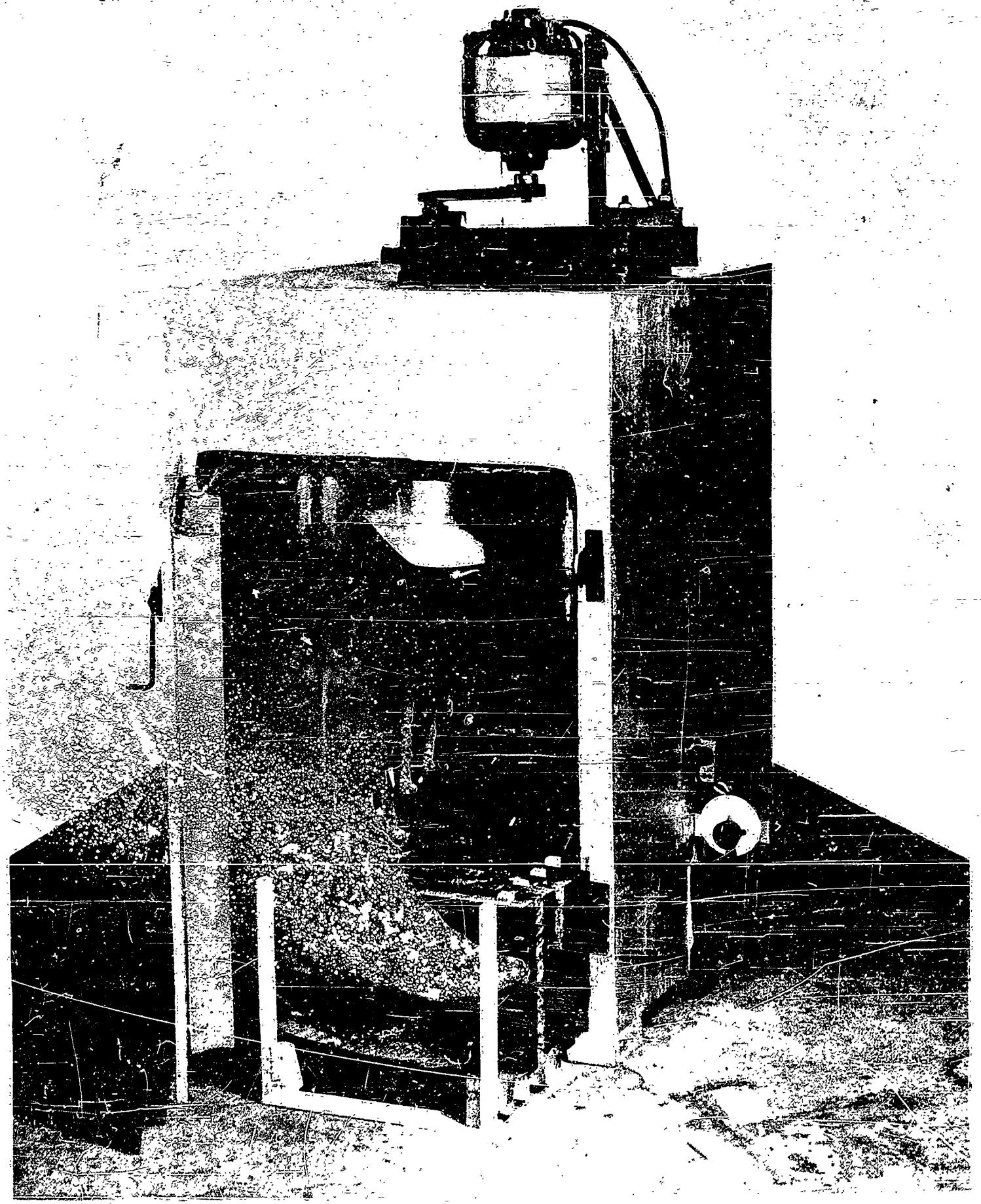


Plate 2. View of the interior of the pilot kiln with a load of Determa lumber. Spaces in the center of the load were occupied by sample boards during the run.

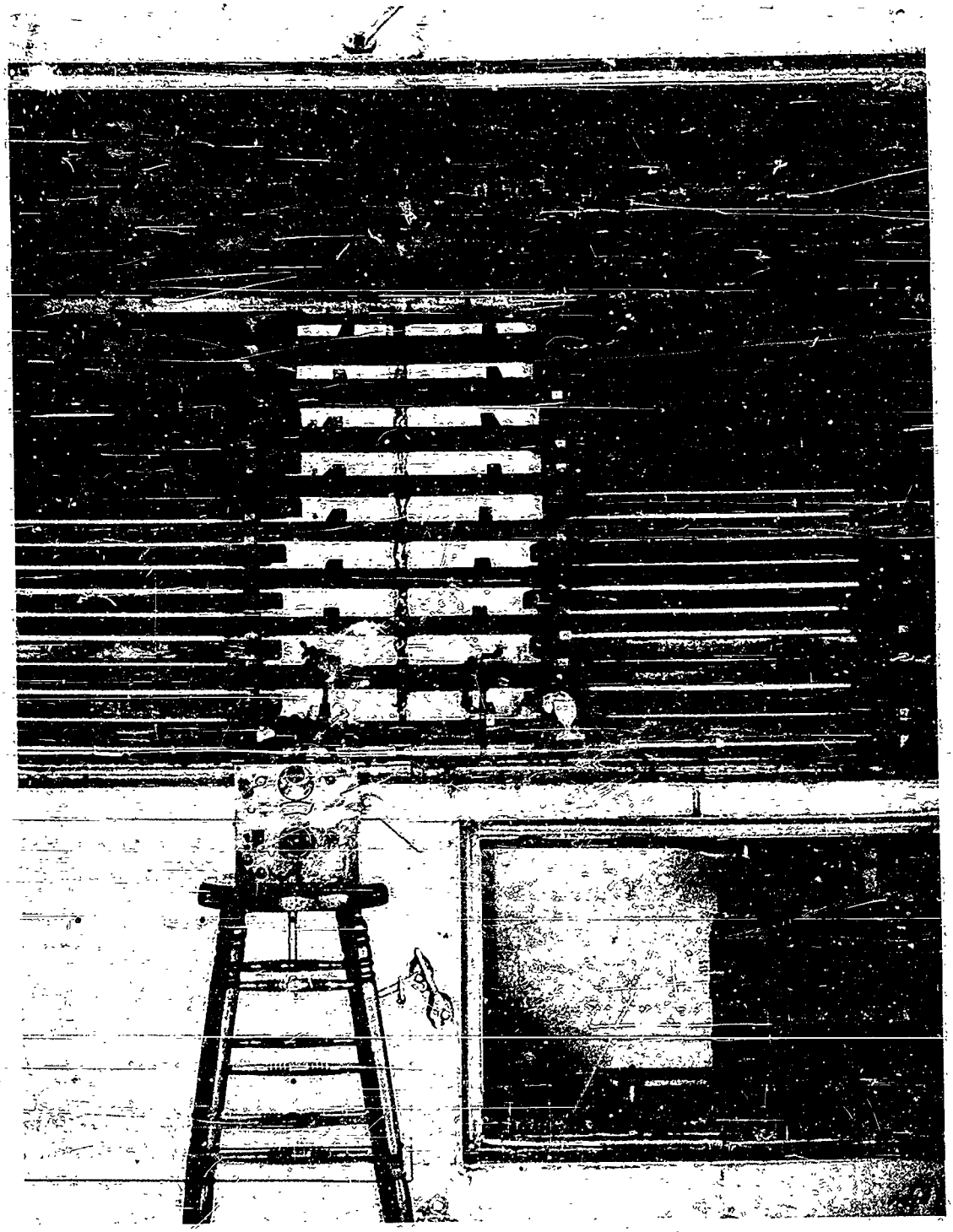
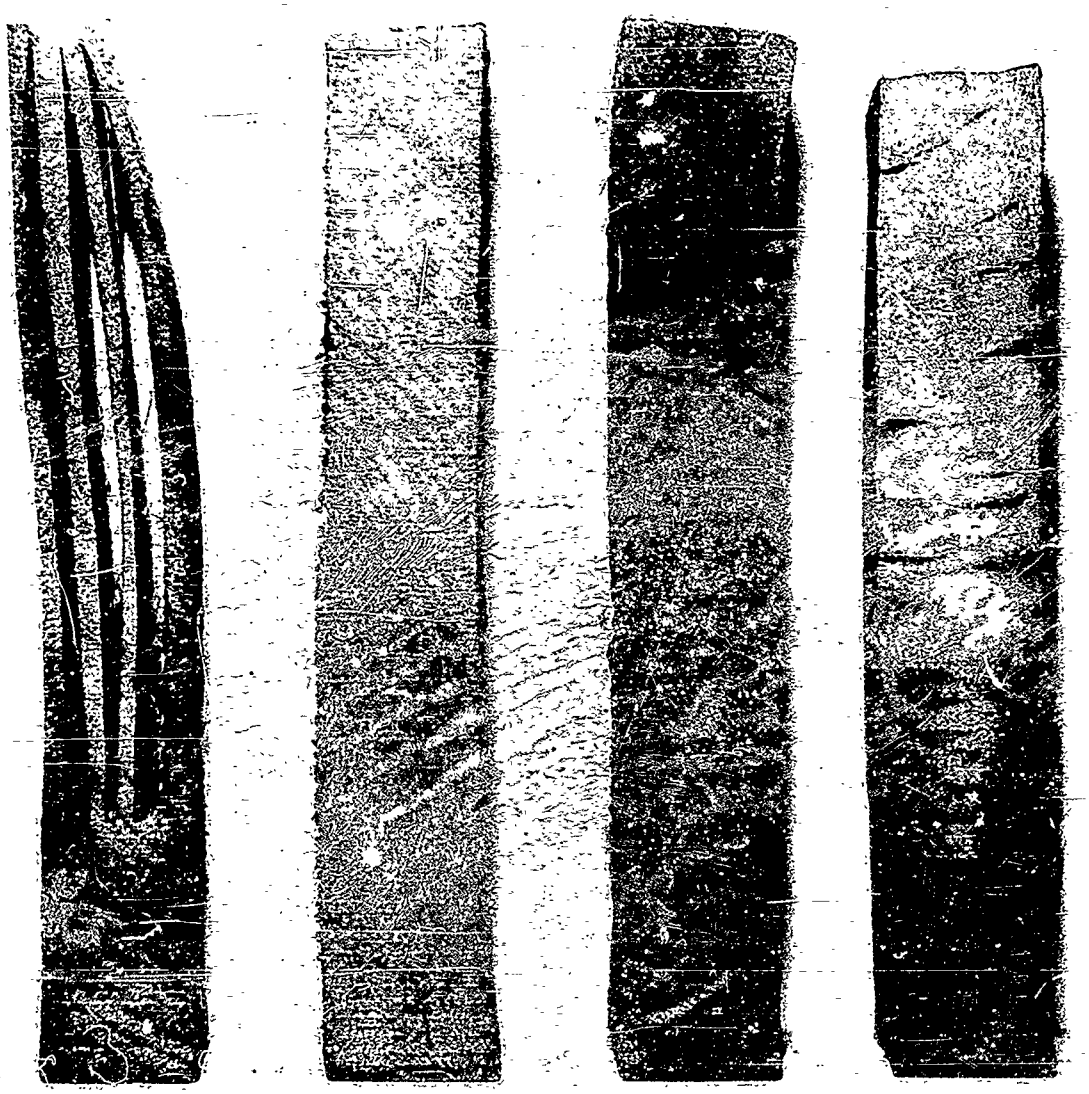


Plate 3. Seasoning defects occurring in Determa lumber. A, stress section showing casehardening developed during kiln drying; B, C, and D, collapse, honeycombing, and surface checking resulting from too severe drying conditions.



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Materials (Non-Metallic) (14)
Wood (10)

Wood - Strength
Wood - Moisture content

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